

DISSERTATION
DEFENSE

*Numerical Optimization for Transport and Registration
Problems*

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Abstract: In this talk three studies will be presented; the first two are application driven, addressing the challenging volume preserving image registration and optimal mass transport problems. The third study is more generic and embarks at the development of a new inexact sequential quadratic programming framework, which can be utilized for a variety of problems.

Image registration aims at finding a plausible transformation which aligns images taken at different times, different view-points or by different modalities. This problem is ill-posed and therefore, regularization is required. In that study, elastic regularizer is considered along with volume preserving constraint. A numerical framework based on augmented Lagrangian along with geometrical multigrid preconditioner was devised. The proposed algorithm was tested with real data.

The optimal mass transport seeks for an optimal way to move a pile of soil from one site to another using minimal energy, while preserving the overall mass. In that study, a fluid dynamics formulation was considered. This formulation introduces an artificial time stepping, which on the one hand transforms the non-convex problem to a convex one, but on the other hand increases the dimensionality of the problem. A Schur complement and algebraic multigrid formed a preconditioner within a sequential quadratic programming scheme. Results for both three dimensional as well as four dimensional problems were presented.

As the two problems above indicated, discretize-then-optimize approach entails large-scale optimization problem. Inside each step of nonlinear optimization, solution for an ill-conditioned, indefinite linear system, known as a KKT system is required. As problem size increases, linear iterative solvers become the bottleneck of the optimization scheme. Although custom-made solutions for each problem can be formulated, more generic resolution is often desired. In the third study, a new approach for inexact step computation is proposed. The general idea is to reduce the number of linear iteration while still maintaining convergence of the overall scheme. This is done, by the embedment of a filter inside a linear solver. The filter serves as decision-maker for step acceptance, and thereby offers robust, and yet prompt convergence.

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